Original Article

Enhancing Total Knee Arthroplasty Recovery through a Telehealth Physical Activity and Behavior Modification Program: A Randomized Controlled Trial

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ABSTRACT

Background: Total knee arthroplasty (TKA) is mainly performed for patients with end-stage knee osteoarthritis (OA), and effective rehabilitation is essential for recovery. Traditional rehabilitation methods can exclude some patients due to access issues, making telehealth a viable alternative. This study aimed to evaluate the effectiveness of telehealth-based rehabilitation in improving functional recovery, reducing pain, ensuring program adherence, and assessing patient satisfaction after TKA.

Methods: This randomized controlled trial (RCT) included, 30 TKA patients that were divided into telehealth-based rehabilitation (n=15) or conventional, in-person rehabilitation groups (n=15). Functional mobility (Timed Up and test), perceived pain levels (Visual Analog Scale), adherence rates, and patient satisfaction were evaluated at baseline and 6 weeks post-operatively. Intention-to-treat analyses were performed for all data.

Results: The findings from this study revealed that patients improved more in functional mobility over time on telehealth compared with standard rehabilitation (mean differences in timed-up and test: 4.2s vs. 2.5s, $p<0.05$) and also pain reduction (VAS score: 3.1 vs. 1.9, $p<0.05$). Thus, telehealth showed improved adherence rates (92% vs. 78%) and also proved to show patient satisfaction levels significantly higher ($p<0.01$).

Conclusion: Telehealth-based rehabilitation with behavior modification presents a feasible and effective alternative for TKA recovery compared to traditional rehabilitation. Functional outcomes, pain management, and patient adherence improve with telehealth rehabilitation, thus making this approach more accessible. Future studies could investigate the long-term outcomes and hybrid rehabilitation designs.

Keywords: Behavior modification, Functional recovery, Pain management, Telehealth rehabilitation, Total knee arthroplasty.

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INTRODUCTION

Total knee arthroplasty (TKA) is usually known as knee replacement surgery, the most commonly performed orthopedic surgery[1]. It is used for the relief of pain and restoration of function in patients with pain of severe OA with or without other crippling diseases[2]. Indeed, due to ageing populations and high obesity rates, the number of people with OA has become ever more significant, making TKA one of the most frequently conducted surgical interventions worldwide[1-2]. While considerably relieving pain and increasing mobility, post-operative recovery after TKA becomes difficult for many patients[3]. Pain, stiffness, weakness, and limited range of motion usually persist for several months after surgery, thus affecting functional outcomes and quality of life[4]. This necessitates the critical focus towards post-TKA recovery strategy optimization in orthopedic practice and rehabilitation medicine[5].

Traditional post-TKA rehabilitation features face-to-face PT sessions for patients, education, and supervised exercise programs[6]. Such programs, however successful, usually face accessibility issues, the need for travel, time constraints, and barriers to access related to older adults and those who live far away[7]. As healthcare systems are moving entirely into digital health services, telehealth-based rehabilitation programs have entered the fray, competing as strong alternatives for traditional rehabilitation[8]. It aids in personalizing the use of digital platforms, mobile applications, and virtual consultations to present customized, individualized physical activity interventions, education, and behavioral support remotely[9].

The most important factors that affect successful TKA recovery include following up with physical activities and rehabilitation exercises[10]. Studies show that patients usually fail to continue their advised post-operative rehabilitation[11]. Patients often cite lack of motivation, fear related to pain, or absence of clear guidance as the most common reasons for discontinuation during a post-operative period[11]. Behavioral modification strategies targeting goal-setting, self-monitoring, cognitive-behavioral therapy (CBT), and motivational interviewing have recently increased as sought-after tools for enhancing adherence to physical activity regimens[12]. These strategies could enhance patient engagement and self-efficacy and maximize recovery when integrated into telehealth interventions.

Telehealth for orthopedic rehabilitation has significantly gained pace within the COVID-19 pandemic that has virtually insisted on remote delivery of health services[13]. Evidence has shown that telehealth rehabilitation programs work comparable to traditional in-person PT in significant functionality improvements after TKA[14].

Furthermore, these programs are cheaper, more accessible, and more convenient for patients[15]. However, more research is still needed to assess the long-term impact of telehealth-based physical activity and behavioral modification programs on TKA recovery, patient satisfaction, and overall healthcare expenditure. Thus, the research investigated the effectiveness of telehealth-based physical activity and behavior change treatment in augmenting recovery from TKA. Addressing gaps within current rehabilitation paradigms, this research aims to bring to life a further understanding of the impact of digital health-related interventions on recovery and improvements to patient-cent red care post-TKA.

METHODOLOGY

This randomized controlled trial (RCT) was conducted to assess the effectiveness of a telehealth-based rehabilitation for modifying physical activity behaviors in post-operative recovery following TKA. The study adhered to CONSORT guidelines to assure methodological rigor and transparency[16].

Sampling Frame and Technique

All patients due for primary knee replacement surgery were recruited from three tertiary hospitals in Islamabad. Purposive sampling was adopted to obtain homogeneity in baseline characteristics. In order to minimize the selection bias, block randomization was employed by which an equal number of patients was assigned into groups.

Sample Size and Group Allocation

Thirty subjects were enrolled in this study, and 15 patients were assigned to each group via a computer-generated random sequence. Block randomization was used for equal group sizes to minimize selection bias. The subjects were subdivided into smaller blocks (i.e., blocks of four or six) before randomly assigning them to either the intervention or the control group in each block. The intervention group completed a telehealth rehabilitation program, while the control group attended standard, in-person therapy. To avoid allocation bias, the allocation sequence was concealed using consecutively numbered, sealed opaque envelopes.

Sampling Criteria

Patients with end-stage Knee OA aged 50 to 75 years eligible for unilateral primary TKA, willing to participate in the telehealth rehabilitation or meet for in-person rehabilitation and have access to a smartphone, tablet, or computer with internet connectivity (for the intervention group) were included.

Patients with severe cognitive impairment or other psychiatric conditions resulting in non-compliance and major post-operative complications result in prolonged hospitalization were excluded.

Intervention Group

Telehealth Rehabilitation Program

This telehealth rehabilitation program was structured and six weeks long. It included the following:

- Tele-therapy of physical therapy secured on telemedicine platforms;
- Suitable home exercise program personalized with live video demonstrations and monitoring tools;
- Behavior change strategies, which included goal setting, motivational interviewing, and self-monitoring tools;
- Weekly teleconsultation with a physical therapist was needed to assess progress and support the participants in adhering to the program.

Control

Standard In-Person Rehabilitation

Standard post-TKA rehabilitation included supervised physical therapy, with participants in this group receiving:

- Hospital and outpatient clinical visits for supervised physiotherapy.
- A home exercise program directed by literature with occasional therapist follow-ups.
- Standard post-surgical care as recommended by their orthopedic team.

Outcome Measures

Primary Outcomes

Improvement of functional mobility, assessed by the Timed Up and Go (TUG) test. Pain reduction is measured through the Visual Analog Scale (VAS).

Secondary Outcomes

Compliance with rehabilitation protocols. Patient-reported satisfaction and quality of life using the Knee Injury and Osteoarthritis Outcome Score (KOOS).

Data Analysis

The statistical analysis using SPSS version 27 with a significance level set at $p<0.05$. Standard descriptive statistics were employed to summarize baseline characteristics: mean, standard deviation, and frequency distributions. In addition, paired t-tests control all changes for time within groups, whilst ANOVA takes care of between-within-group effects. An Intention-to-Treat (ITT)-style analysis, using the Last Observation Carried Forward (LOCF) method, accounted for loss-through biases. 95% confidence intervals subsequently ensured reported results to make them statistically robust.

RESULTS

Baseline Characteristics

A total of 30 subjects were randomly allocated into two equal groups: Rehabilitation telehealth (n = 15) and standard rehabilitation in-person (n = 15). Both groups did not differ in either age, gender, BMI, or preoperative knee function ($p>0.05$), ensuring homogeneity between them. The average age of the participants was 65±5 years, and 60% were female.

Primary Outcomes

Dynamic Balance (Timed Up and Go Test)

At baseline both groups had similar TUG times (14.5±2.3 sec vs. 14.6±2.4 sec, $p=0.91$). Measured six weeks post-treatment, improvement was greater for the telehealth (9.9 ± 2.0 sec) than for the standard rehabilitation group (11.8±2.3 sec; $p=0.03$) (Table-1).

Pain Reduction (Visual Analogue Scale - VAS)

Preoperative, groups were similar regarding VAS: 7.2±1.1 vs. 7.1±1.2, $p=0.87$. On the sixth week, pain was considerably less for the telehealth group (VAS, 2.7±1.4) than standard across (VAS, 3.9±1.6, $p=0.02$) (Table-1).

Secondary Outcomes

Adherence to Rehabilitation Protocols

More adherence from telehealth was recorded, 92% against the standard group, 78% ($p=0.01$). Greater flexibility and virtual personalized support were cited as attributes by the participants of the telehealth program for adherence (Table-2).

Table-1 Comparison of Primary Outcome Measures

Outcome Measure	Duration	Telehealth Group (n=15)	Standard Group (n=15)	p-value
TUG Test (s)	*Baseline*	14.5±2.3	14.6±2.4	0.91
	6 Weeks	9.9±2.0	11.8±2.3	0.03
VAS Pain Score	*Baseline*	7.2±1.1	7.1±1.2	0.87
	6 Weeks	2.7±1.4	3.9±1.6	0.02

Patient Satisfaction and Quality of Life (KOOS Score)

KOOS scores were significantly higher by six weeks at 78.5±5.7 in telehealth and 72.3±6.1 in standard (p=0.04). Telehealth participants declared higher self-reliance in managing rehabilitation, stating the great advantage of behavior modification strategies (Table-2).

Table-2 Comparison of Secondary Outcome Measures

Outcome Measure	Duration	Telehealth Group (n=15)	Standard Group (n=15)	p-value
KOOS Score	*Baseline*	52.1±6.3	51.8±6.5	0.89
	6 Weeks	78.5±5.7	72.3±6.1	0.04
Adherence Rate (%)	*6 Weeks*	92%	78%	0.01

DISCUSSION

Patients who went through telehealth rehabilitation achieved significantly better outcomes in terms of recovery post-TKA than those who underwent rehabilitation in the traditional form of visiting an outpatient facility. In particular, participants in the telehealth program demonstrated performance gains in functional mobility (TUG), pain reduction (VAS score), a higher proportion of adherent patients, and higher satisfaction than did their typical counterparts receiving in-clinic rehabilitation. These observations indicate that telehealth rehabilitation offers a viable and effective alternative therapy to traditional therapy of face-to-face formats.

The more significant functional mobility improvements observed in the telehealth group are consistent with previous studies. Evidence indicated that supervised home rehabilitation often compares to or improves upon traditional in-clinic therapy[17-18]. The telehealth group had a significantly higher adherence rate than the face-to-face group (92% vs 78%), further bolstering the idea that patients can attend rehab more often when they get the benefit of having therapy done in a flexible, home-based manner[19]. Additionally, the difference in pain relief between groups was magnified since the telehealth method included some behavior modification strategies. Evidence from earlier studies indicated that cognitive-behavioral techniques and education in self-management were effective in improving pain outcomes for musculoskeletal conditions[20]. Patients in the telehealth group achieved more excellent satisfaction scores, implying heightened confidence in self-management, which is important in enhancing post-operative recovery[20].

Our findings supplement earlier systematic evaluations and randomized trial assessments of telehealth-based rehabilitation for TKA[21-22.] In a Pastora-Bernal et al.[18] similar functional and pain improvements were observed between telehealth and face-to-face rehabilitation conditions, indicating the feasibility of remote rehabilitation programs. However, this continues the evidence as it includes behavior modification strategies, explaining better adherence and satisfaction noted in the telehealth group.

Motivating and self-efficacy thus become the determinants of success in rehabilitation, which stems from a study by Delahanty et al.[23] that emphasized the psychosocial factors. These findings complement telehealth as, in addition to being more adherent, patients also tend to exhibit more confidence in managing their rehabilitation regimen. Without a doubt, these findings promise the students well about telehealth services; however, next to that is also the limitation of using telehealth due to the digital divide. Baroni et al.[24] stated that low-digital literate patients or lack of a technology-aided facility have been seen as an impediment to accessing telehealth rehabilitation. Future studies may explore methods that would increase accessibility and digital inclusion.

Strengths

Telehealth rehabilitation combined with behavior modification techniques is undoubtedly a new concept in TKA recovery research. This is yet to be widely studied. The randomized controlled design of the current study adds to its rigor and thereby adds validity to the findings, guarding them against selection bias or confounding effects. The study incorporates several aspects of recovery, such as functional mobility, pain, adherence, and patient satisfaction. Hence, it does an overall assessment of rehabilitation effectiveness.

Limitations

With only 30 participants, the findings should be used carefully, and further such studies are warranted to validate with larger cohorts. Six weeks hardly gives a chance to capture long-term functional and pain outcomes. Future research must consider when and if those benefits continue to be held over months and years. Some patients may have telehealth access issues due to minimal technological access or poor digital literacy, causing possible selection bias.

Recommendations

As part of longitudinal studies, results should demonstrate telehealth-based rehabilitation benefits after 6 months or longer. Research should take patients from different parts of the socioeconomic and geographical spectrum to improve generalization. Extensive studies should consider designing rehabilitation models combining telehealth and physical in-person visitations as accessibility models ruin the overall benefit of telehealth programs.

CONCLUSION

The study presented substantial evidence in favor of telehealth rehabilitation along with behavioral modification for being a satisfactory alternative to conventional face-to-face therapy for the post-operative recovery of TKA. Patients in the telehealth group were enhanced clearly in functional mobility, overall pain reduction, adherence, and satisfaction scores. These findings indicate that digital rehabilitation can increase access and engagement in post-operative self-management. As telehealth continues to penetrate healthcare, this will more likely enhance outcomes in traditional TKA rehabilitation while addressing the logistics and accessibility issues.

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None.

Author Contributions
Muhammad Kamran contributed to the study's conception and design. **Ahsan Taqweem** was responsible for data collection and initial analysis. **Marium Riaz** performed statistical analysis and data interpretation. **Tehseen Akhtar** contributed to literature review and manuscript drafting. **Rooh-ul-Husnain Khizar** provided critical revisions and technical insights**. Sana Tariq** assisted in manuscript writing and final proofreading. All authors reviewed and approved the final version of the manuscript.

Ethical Approval
This study received approval from the Institutional Ethical Review Committee (STM-IRB-2024-001) of Shifa Tameer-e-Millat University, Islamabad.

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None.

Conflict of Interests
None.

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